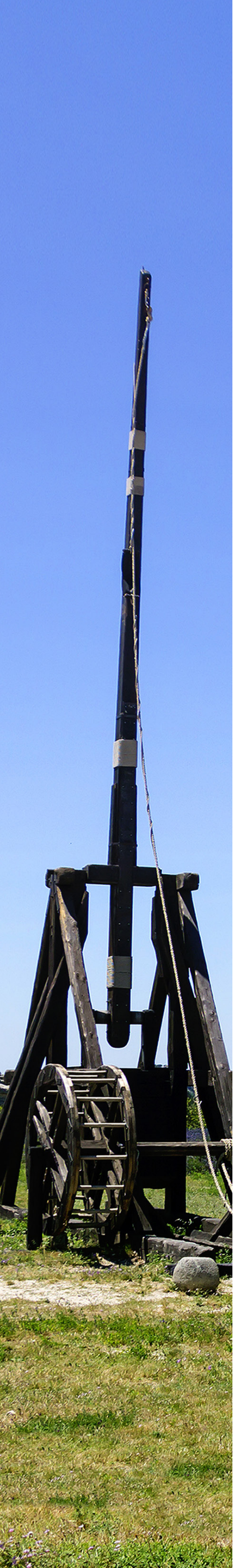


Grades
3–5, 6–8

45–60
minutes

DESIGN A CATAPULT

DESIGN CHALLENGE

Design and build a small-scale catapult to launch a projectile.

SUPPLIES AND EQUIPMENT

Per whole group:

- ◻ Target
- ◻ Hot glue gun (for setup)
- ◻ Projectiles (ping-pong balls, marshmallows, Cheerios, etc.)

Per team:

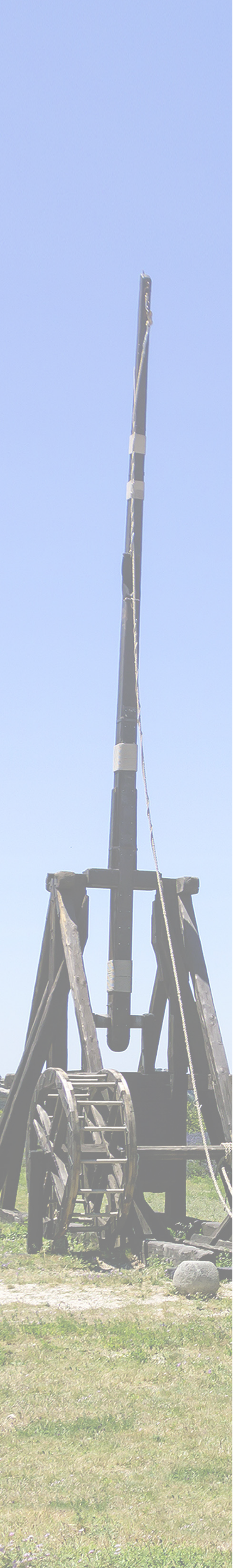
- ◻ 15 craft sticks
- ◻ 20 rubber bands
- ◻ 1 plastic bottle cap

GETTING READY

Use hot glue to attach a plastic bottle cap to one end of a craft stick; this will be the arm of the catapult. Make numerous arms in advance. You may choose to place the bottle cap (or “bucket”) at the end of each stick or vary the bucket location on different sticks to allow for experimentation.

Set up a specific launching zone and a target (bowl, paper target, etc.). The distance between launch zone and target will be dictated by the type of projectile you choose. For younger children, 5 feet is fine; older children may build catapults that can launch a projectile over 20 feet.

Try making a few catapults in advance as examples.



INTRODUCTION

Ask participants questions to determine what they know about catapults and projectile motion.

- What are catapults used for? (Launching objects long distances or over high walls.)
- Can you think of any modern uses of catapults? (Aircraft carriers, pumpkin launching contests; mousetraps are similar to catapults.)
- How would you describe the path of an object thrown by a catapult? (Curved, arc, ascending then descending, etc.)

INSTRUCTIONS

Introduce the design challenge. Working in teams of 2–3, participants will use up to 15 craft sticks (including 1 premade catapult arm) and 20 rubber bands to build a catapult. Projectiles launched by the catapult should consistently hit a paper target.

- Talk with your teammates and plan how your catapult will work. It may help to make sketches to communicate your ideas.
- As a team, decide on a design.

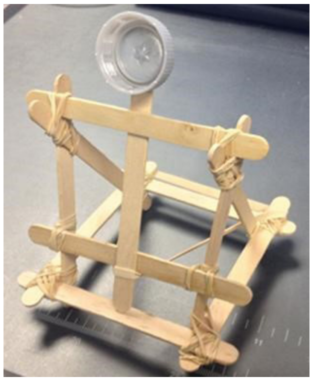
Build a prototype catapult and test it.

- How far does the projectile travel? How high?
- How can you modify your prototype to hit the target?

Participants redesign and adjust catapults until they hit the target.

Evaluate the success of each design.

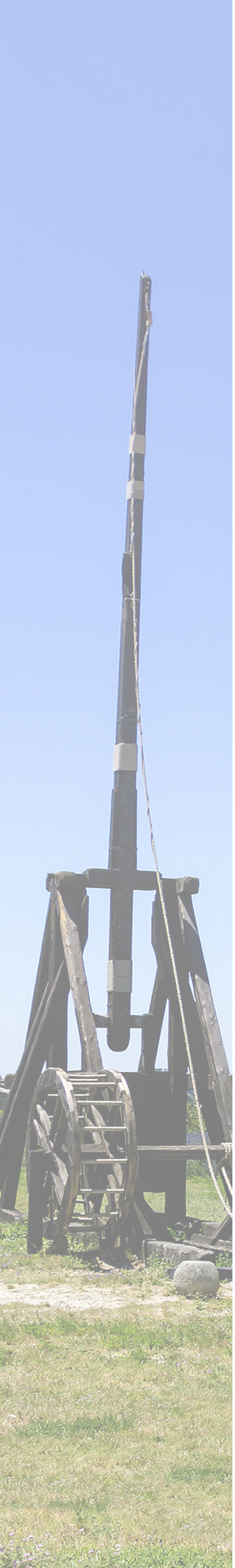
- [ ] Did the catapult launch a projectile?
- [ ] Did the projectile hit the target?
- [ ] Could the catapult consistently hit the target?



Credit: Regents of the University of Colorado.

ACTIVITY VARIATIONS

- Make larger catapults with paint stirrers.
- Challenge participants to design a catapult that can launch a projectile the farthest.



TROUBLESHOOTING

For catapults that are not launching projectiles far enough to hit the target, try:

- Increasing the potential energy of rubber bands by winding or doubling them.
- Moving the bucket farther from the fulcrum.
- Adjusting the angle at which the projectile is released. Aim for 45°.

For catapults that are launching too far, try:

- Adjusting the angle at which the projectile is released.
- Moving the bucket closer to the fulcrum.
- Decreasing tension in rubber bands.

RELEVANT TERMINOLOGY

Lever: A bar that sits on a pivot, like a crowbar or a shovel. Sometimes used to move heavy objects. Catapults are also a kind of lever.

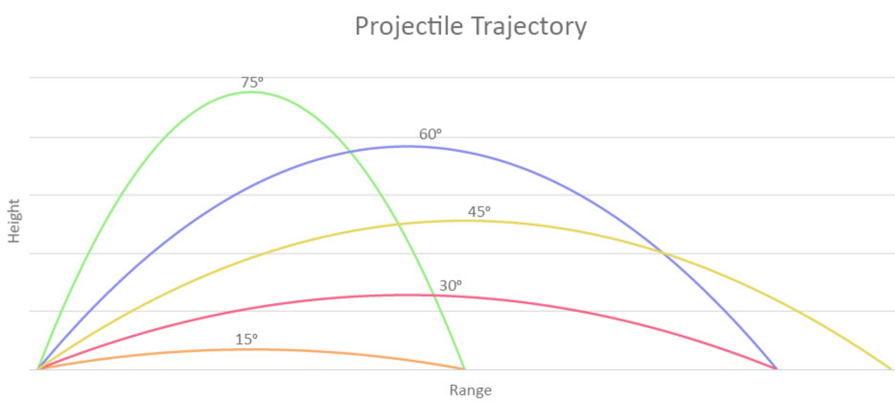
Kinetic energy: Energy of motion. A ball speeding through the air is demonstrating kinetic energy. So are you when you move.

Parabola: A particular curved shape that things launched from a catapult follow.

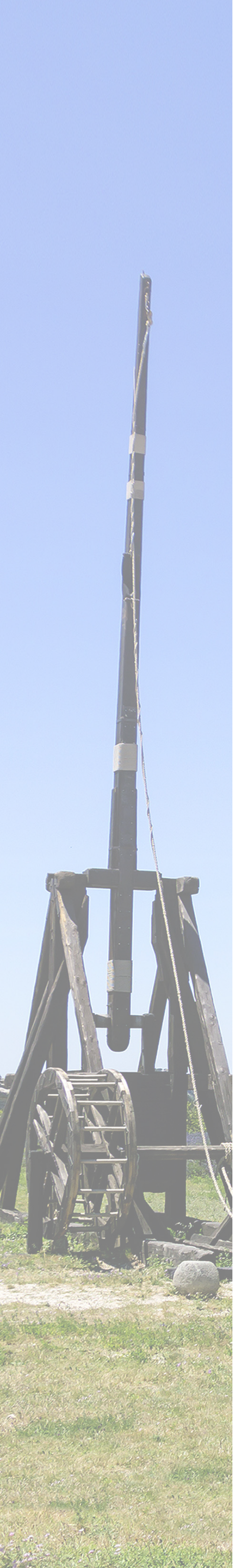
Potential energy: Stored energy. The ball waiting to be launched has potential energy.

Projectile: An object that is launched through the air.

Tension: A force that pulls on both ends of an object and causes it to stretch.



Distance of a projectile launched at different angles. Launch speed is the same in each case. A launch angle of 45° provides the longest flight for a projectile. Credit: Carnegie Science Center.



GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

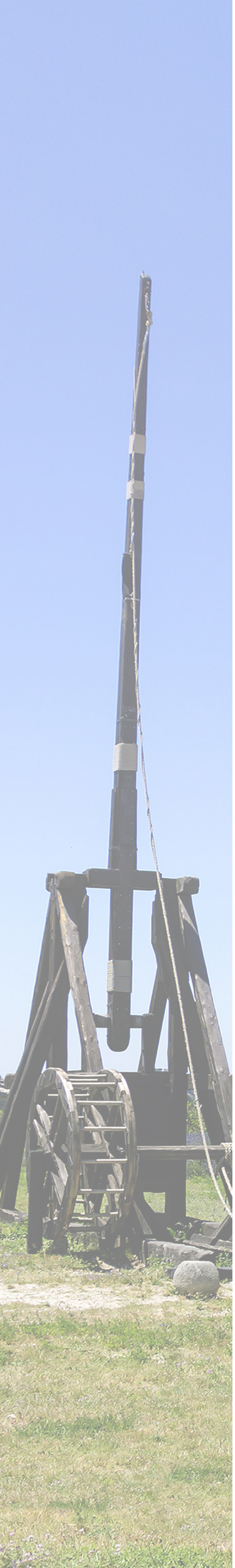
- What materials did you use to build your catapult?
- How did you change the distance traveled by your projectile?
- Were you able to hit the target?
- If your projectile didn't fly far enough, what changes did you make to your design?
- If your projectile flew too far, what changes did you make to your design?

ENGINEERING CONNECTIONS

Engineers have been designing and building catapults for thousands of years. The earliest catapults were invented by the Greeks to improve the power of the crossbow. This type of catapult is called a ballista. Over the ages, many other types of catapults were invented. The earliest catapults used energy from a twisted rope that worked like a rubber band to launch darts, bolts, or spears. Like all good engineers, these inventors were always looking for ways to improve on their design. These improvements, called innovations, led to catapults that had greater power and could throw huge boulders thousands of feet. These giant machines, called trebuchets (pronounced treb-you-shay), used energy from a falling weight to rotate the throwing arm and launch the projectile. According to The Guinness Book of World Records, the most powerful trebuchet threw a 1968 Volkswagen Beetle (weighing nearly 1,700 pounds) over 250 feet!

SCIENCE CONNECTIONS

A catapult is an example of a simple machine known as a lever. Levers are used to reduce the amount of force needed to move an object. To do this, levers are made of a strong bar that pivots on a point called the fulcrum. Think of a seesaw: the strong bar is the part you sit on, and the fulcrum is the part in the middle where the seesaw balances. On a seesaw, the force (an upward kick) is applied to the lever to move another person (or load). Adjusting the length of the lever changes the amount of force required to move the load. If you are on a seesaw with someone who weighs a lot less than you do, you scoot forward so that your weight is closer to the fulcrum while the lighter person sits as far from the fulcrum as possible. That way the lighter person can still move a heavier load.



GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

- How close was your projectile to landing on the target?
- What adjustments did you make to your design to improve its accuracy and consistency?
- How does changing the launch angle affect the distance traveled by a projectile?
- What modifications did you make to change the launch angle?
- What did you use to generate potential energy for your catapult?
- How did you change the amount of potential energy stored in your catapult?

ENGINEERING CONNECTIONS

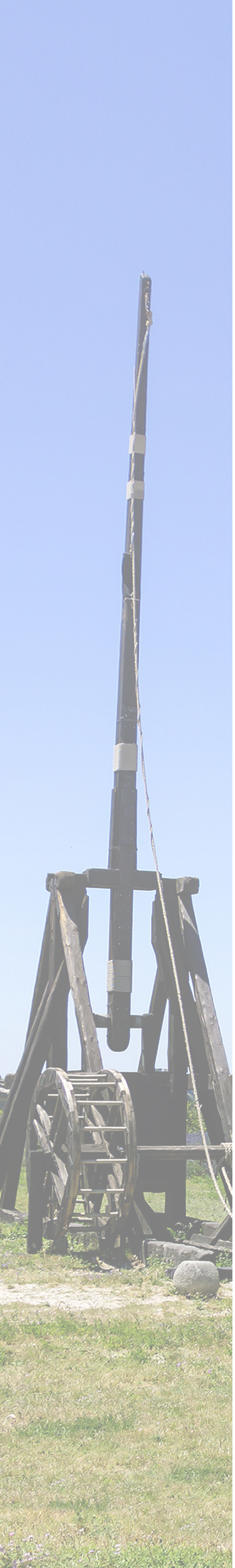
Catapults are machines that help us launch objects. Ancient catapults threw rocks or spears, but are there any modern uses for these devices? Target shooters use catapults to launch skeets, or clay disks, into the air. However, one of the most common modern uses for catapults is launching aircraft.

Aircraft carriers don't have enough room for jets to build up speed for takeoff. Steam-powered pistons push the jet to 165 mph (266 km/h) in 2 seconds. Some new models of aircraft catapults are propelled by electromagnets, which provide smoother operation and put less stress on the jets.

SCIENCE CONNECTIONS

The motion of an object is determined by the forces acting on it. When you launched your projectile, did you notice that it flew in a curved path? There are two forces at work here. First is the force applied by the catapult, which launches the projectile away from the ground. The second is gravity, which pulls the projectile back down to the ground. These two forces combine to make a particular kind of curved path called a parabola. We see this curved path any time a projectile is launched, whether it's a baseball, a long jumper, or even a watermelon seed spit from your mouth!

MacGillivray Freeman's DREAM BIG



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ACKNOWLEDGMENTS

The source of this material is the TeachEngineering digital library collection at www.TeachEngineering.org.

TEACHENGINEERING curriculum for k-12 teachers

teachengineering.org/sprinkles/view/cub_catapult

Supplemental content adapted for *Dream Big* Activities by Carnegie Science Center.

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